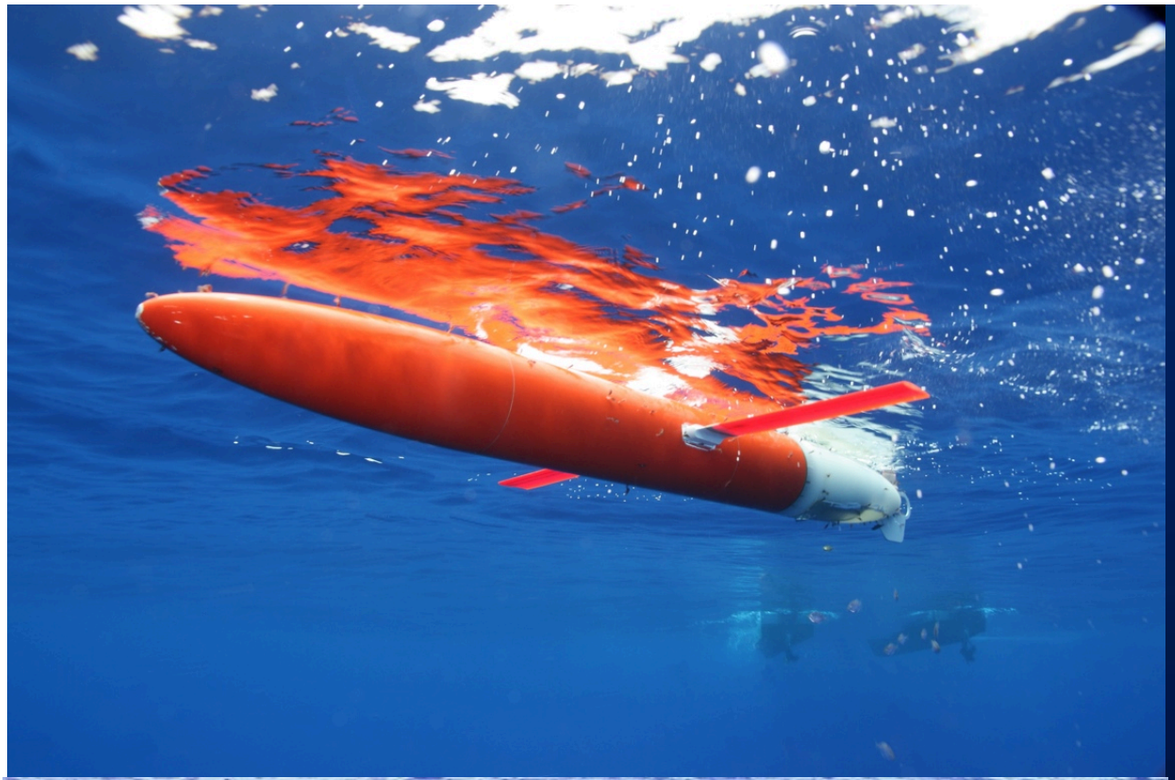
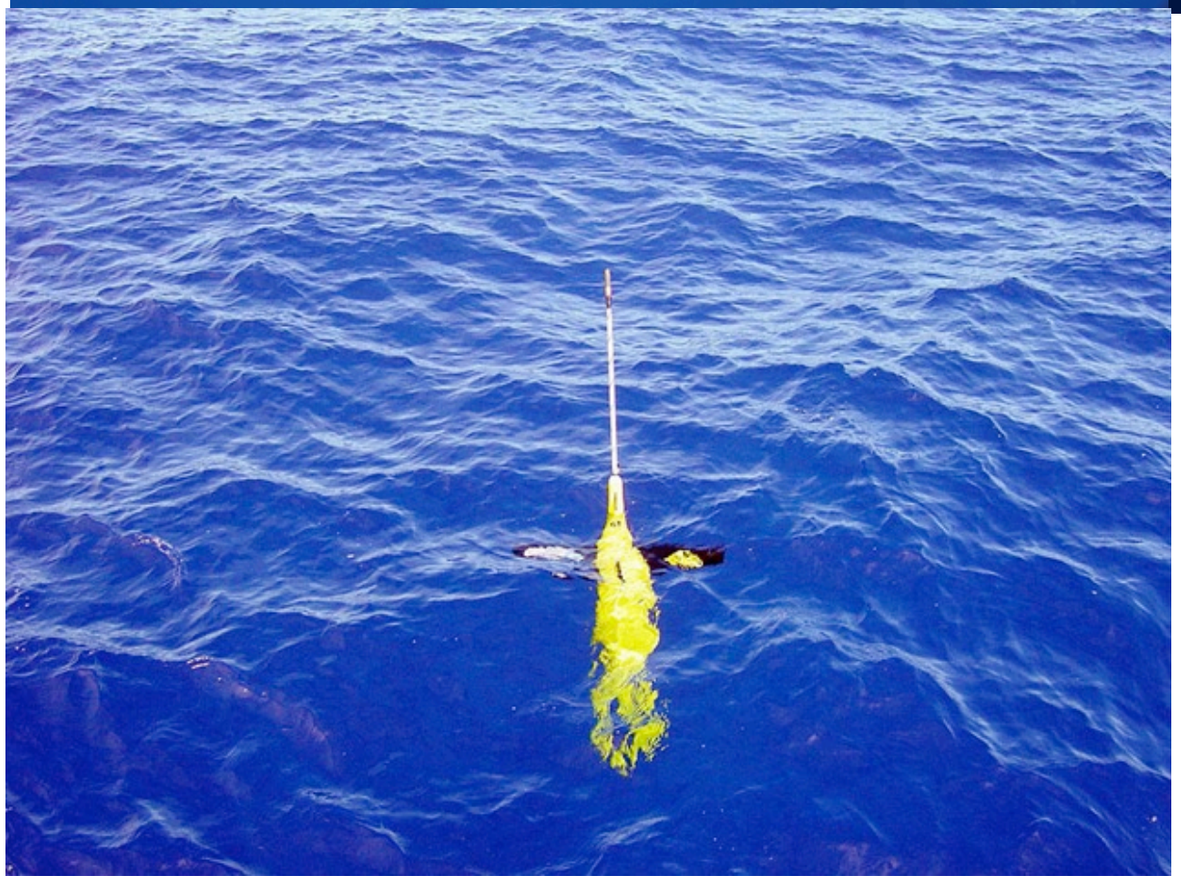


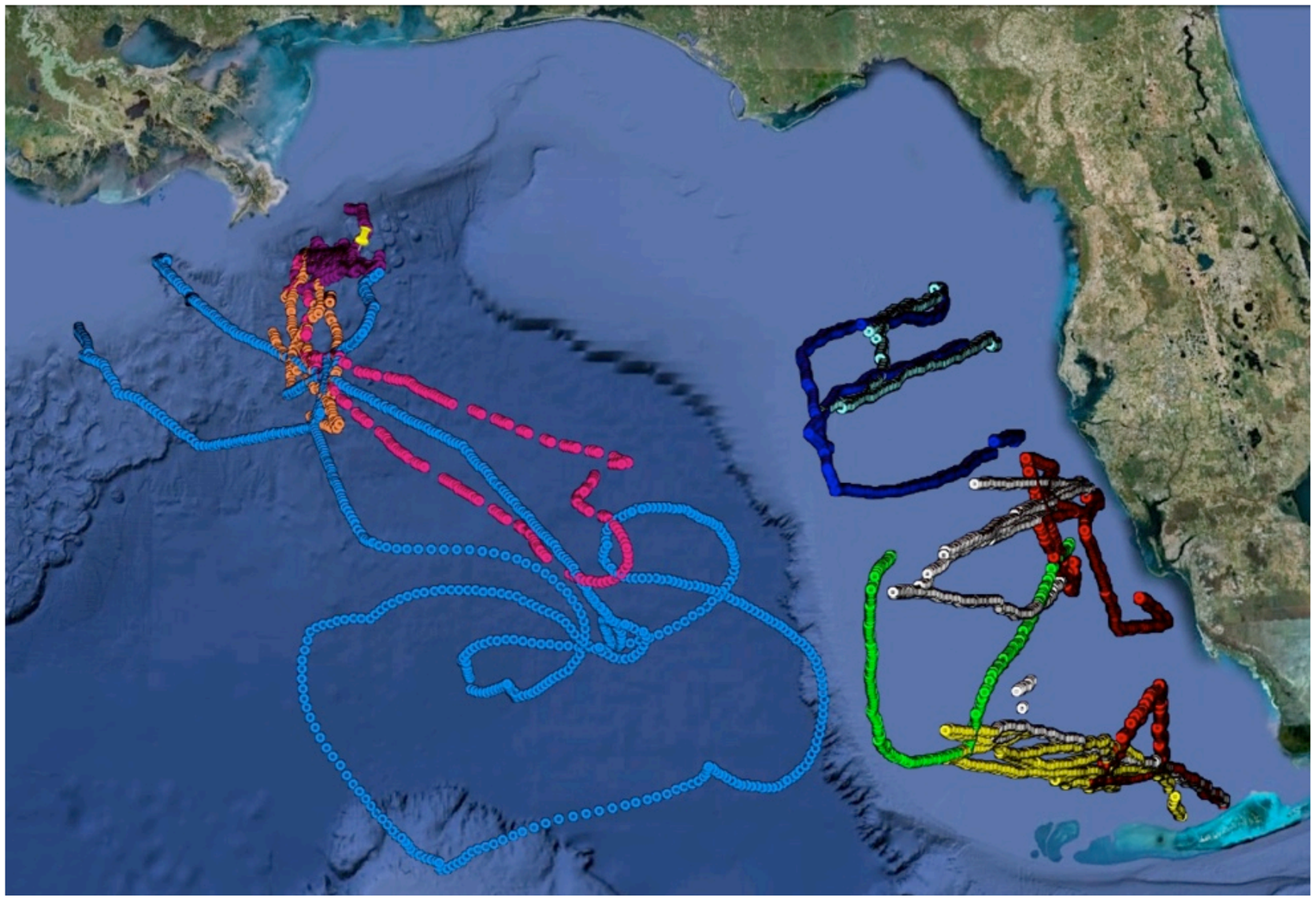


A national glider network for sustained observation of the coastal ocean

Daniel Rudnick, Rebecca Baltes, Michael Crowley, Craig Lee, Chad Lembke, Oscar Schofield

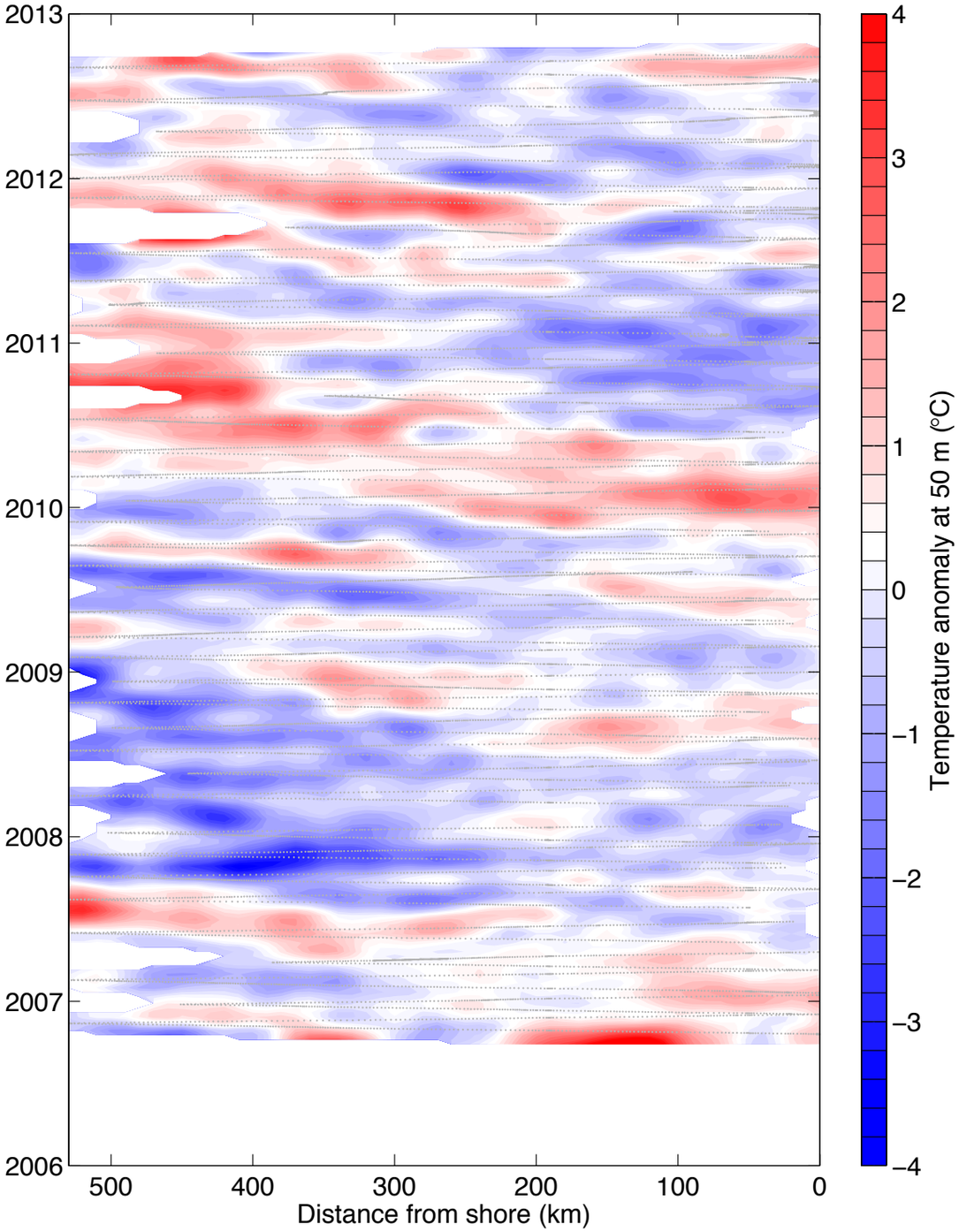
IOOS®
INTEGRATED OCEAN OBSERVING SYSTEM

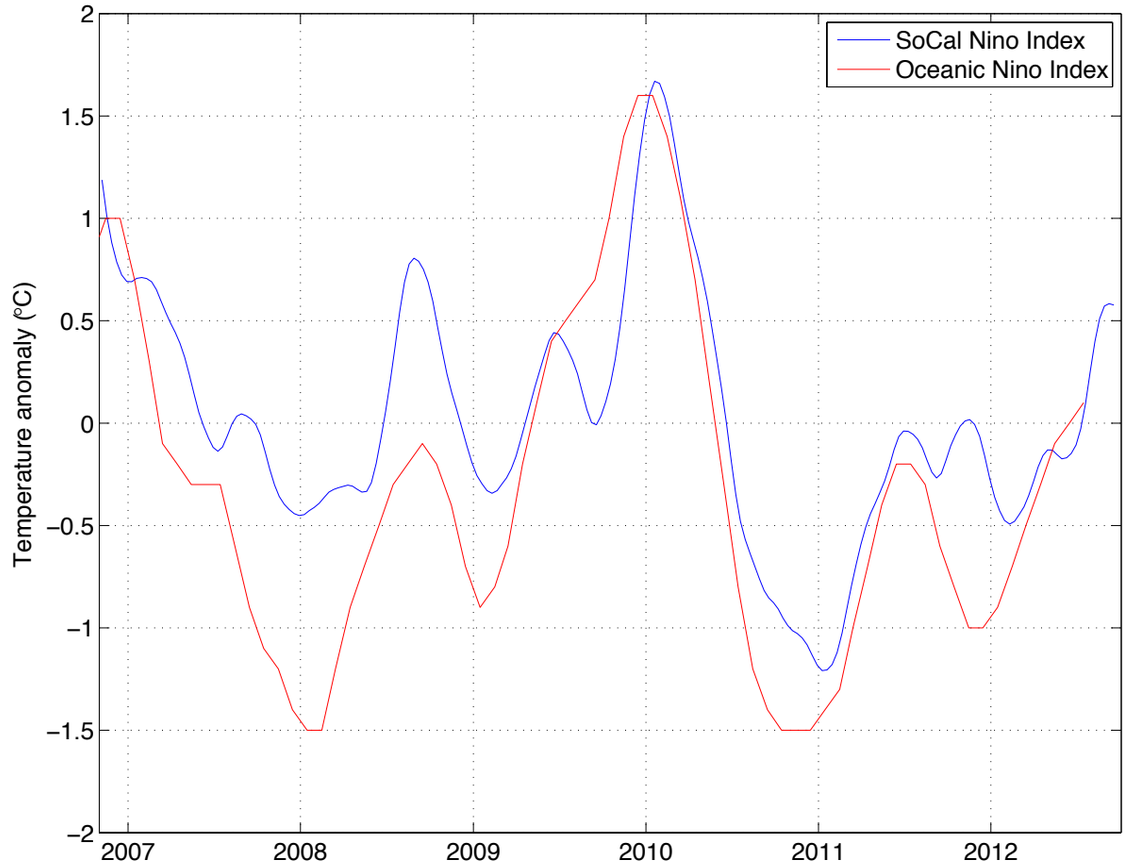
Gulf of Mexico



- National glider fleet deployed within weeks
- Contributions from institutions around the country
- Data distributed in real time
- Assimilation into models

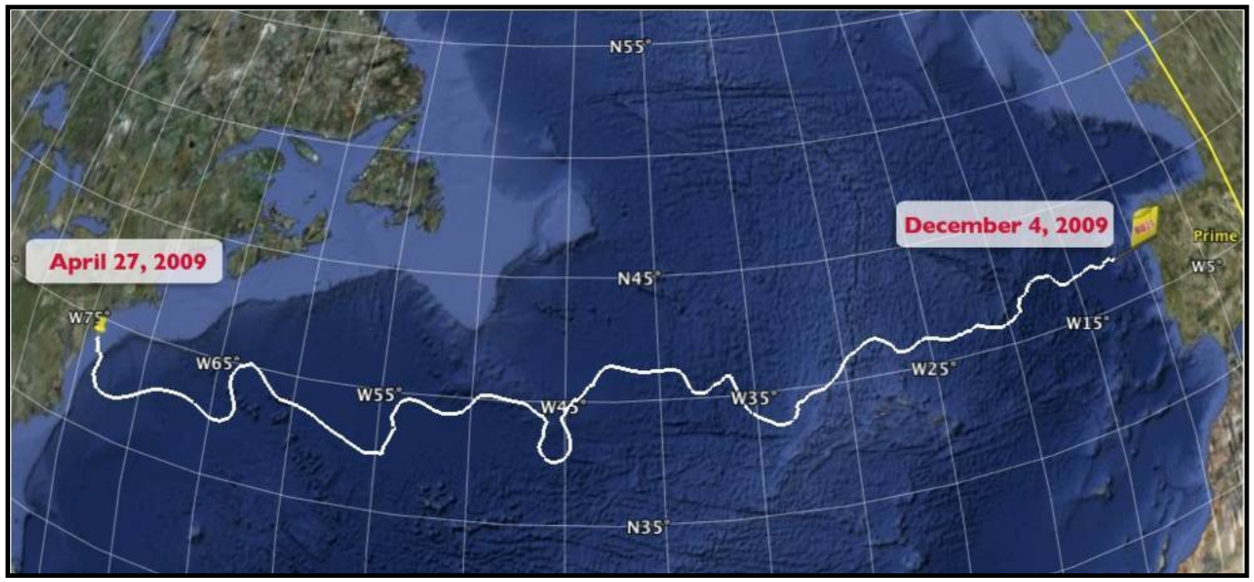
The SoCal Niño Index

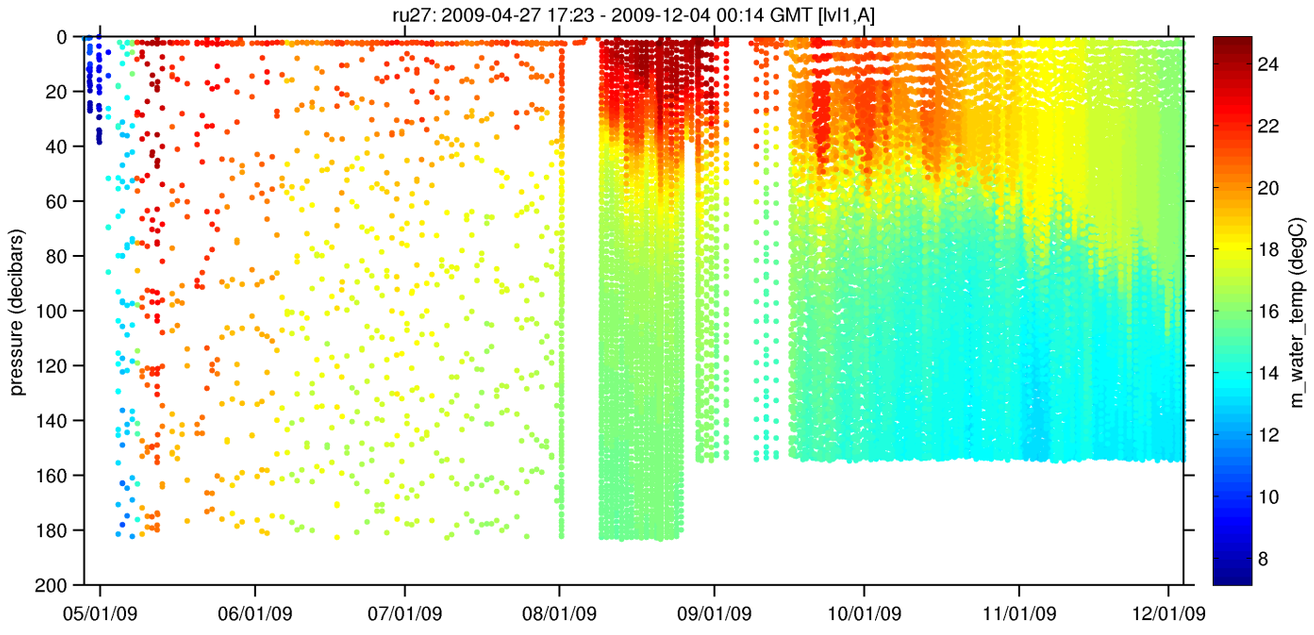


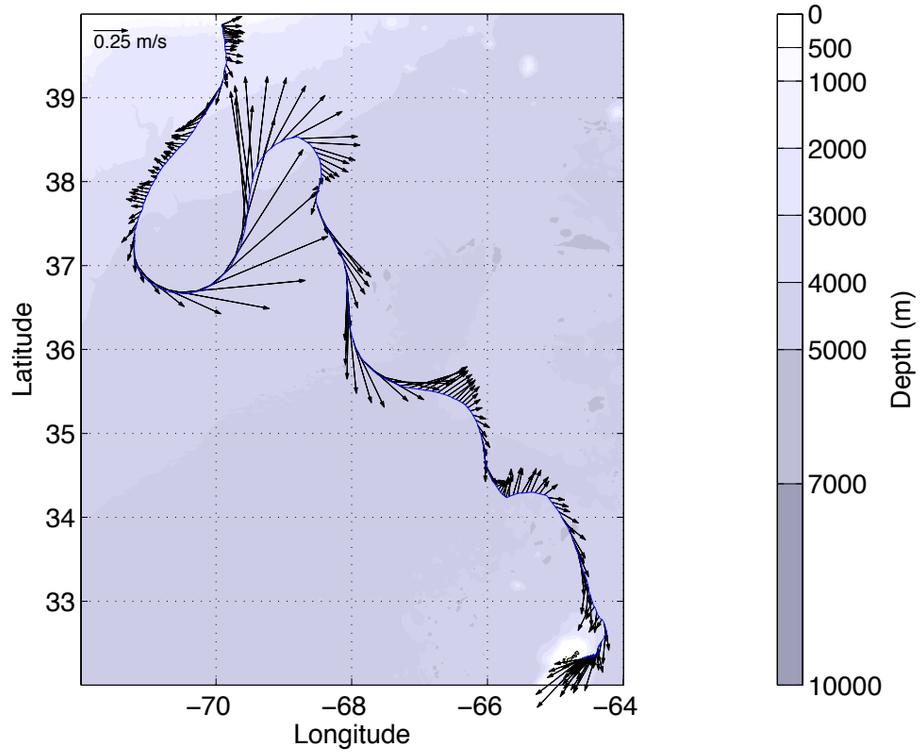


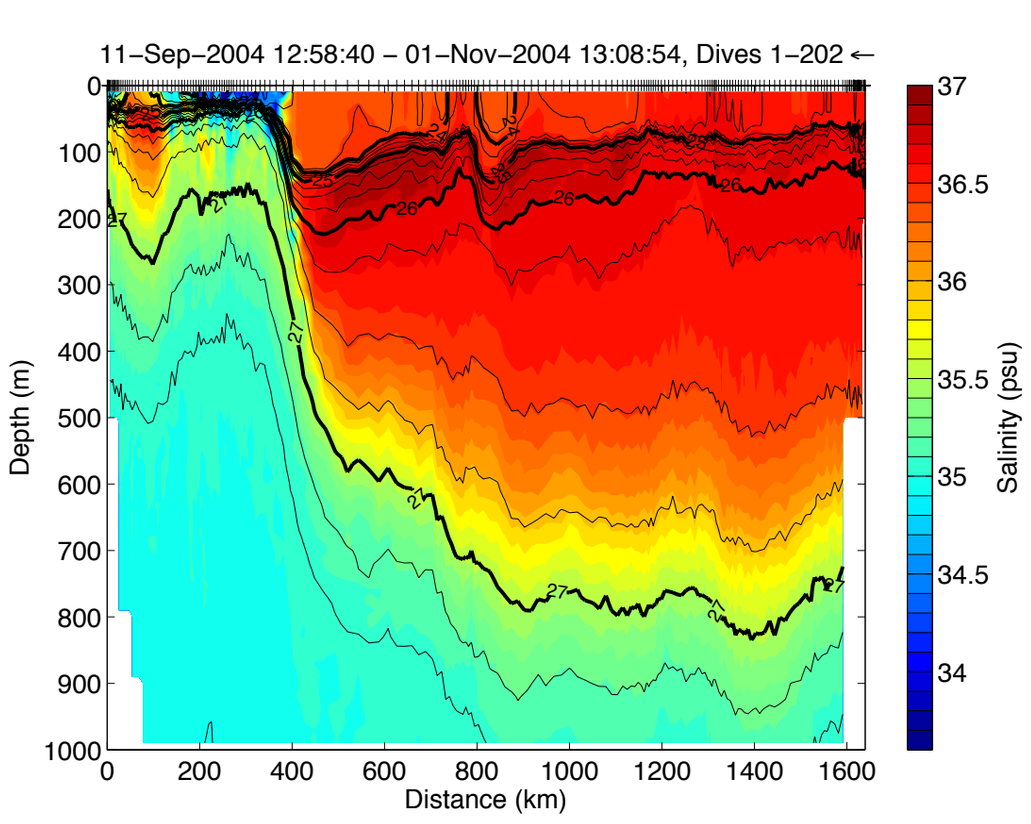
- Temperature anomaly at 50 m
- We are experiencing weak El Niño conditions now.

Gulf Stream



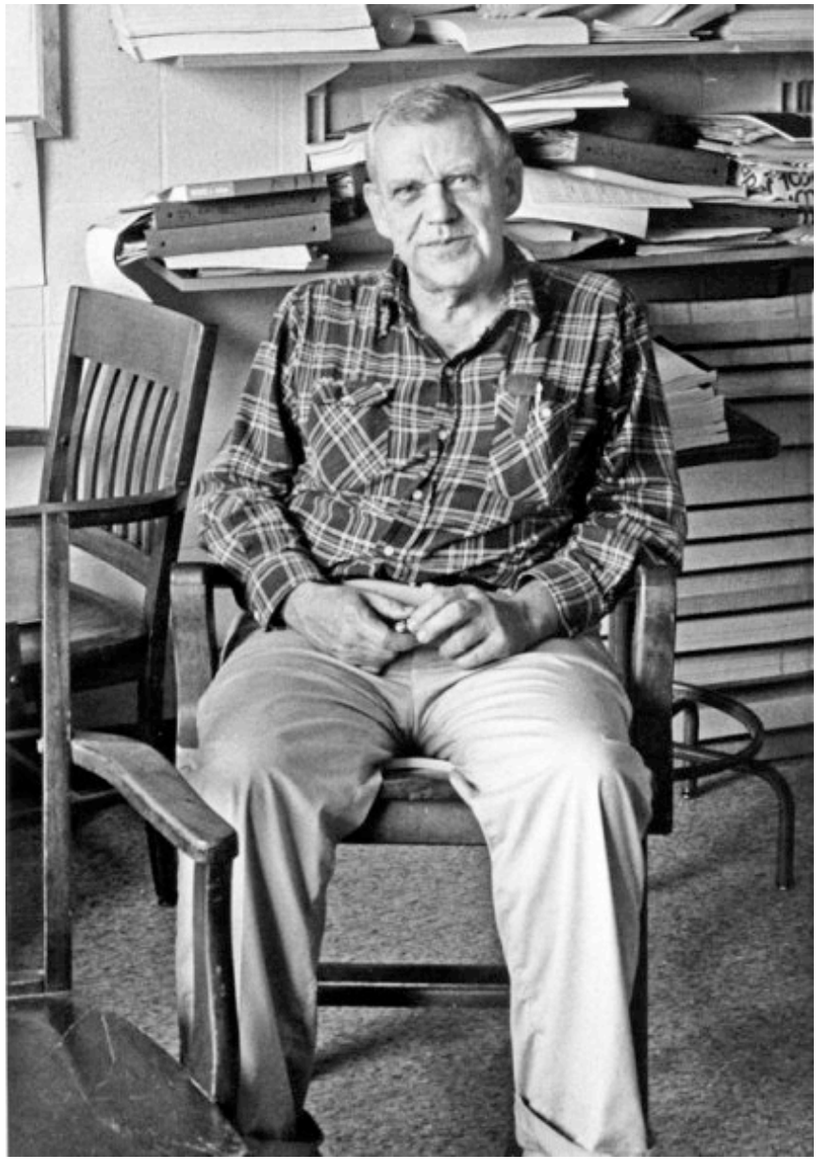




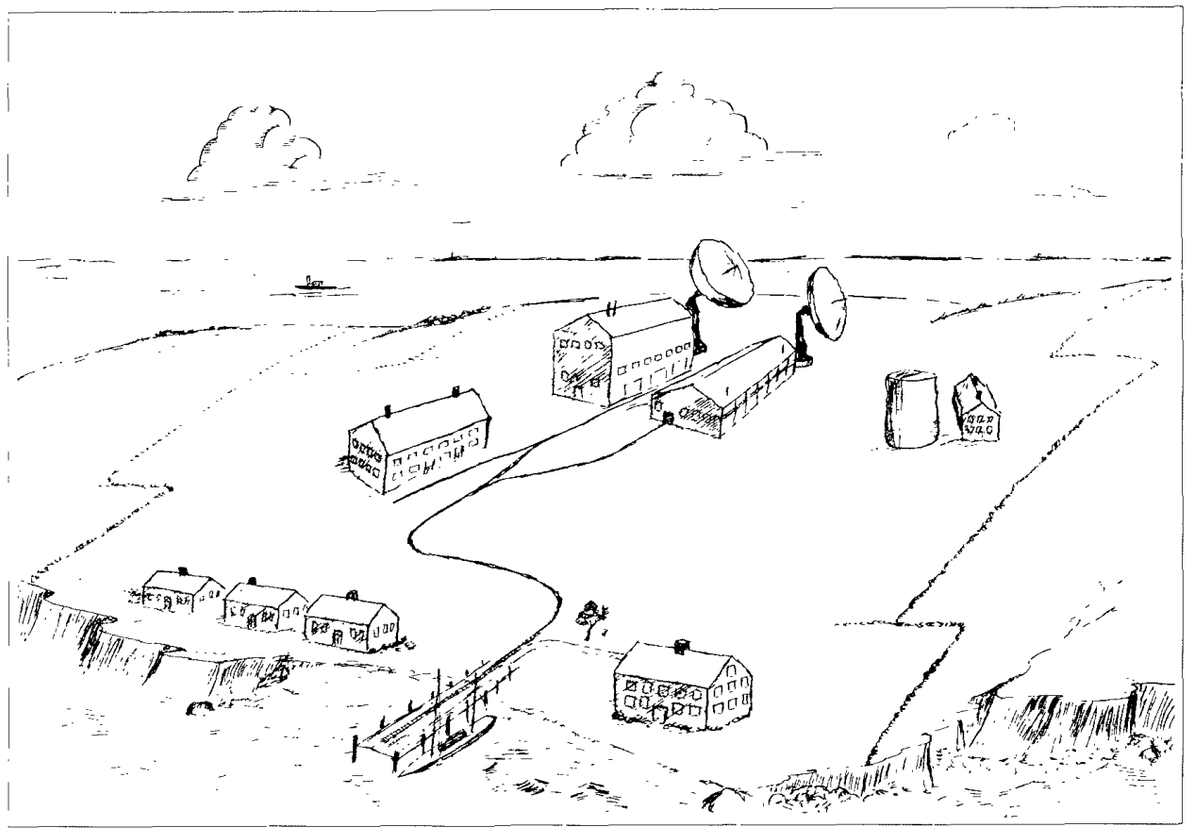


- Cross Atlantic 2009
- Cross Gulf Stream 2004

Stommel's vision



1989

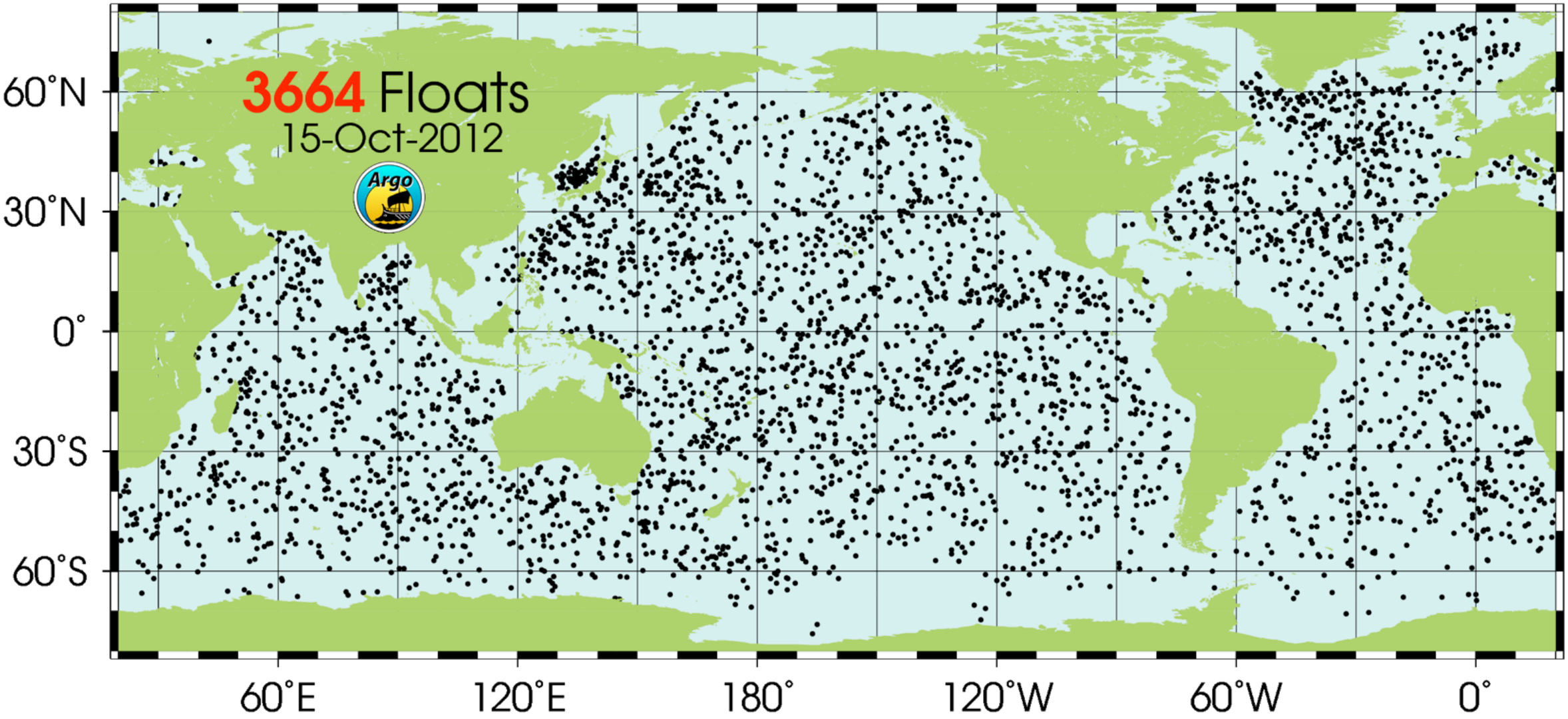


The Slocum Mission Control Center on Nonamesset Island.

Each Slocum reports into Mission Control via satellite about six times a day.

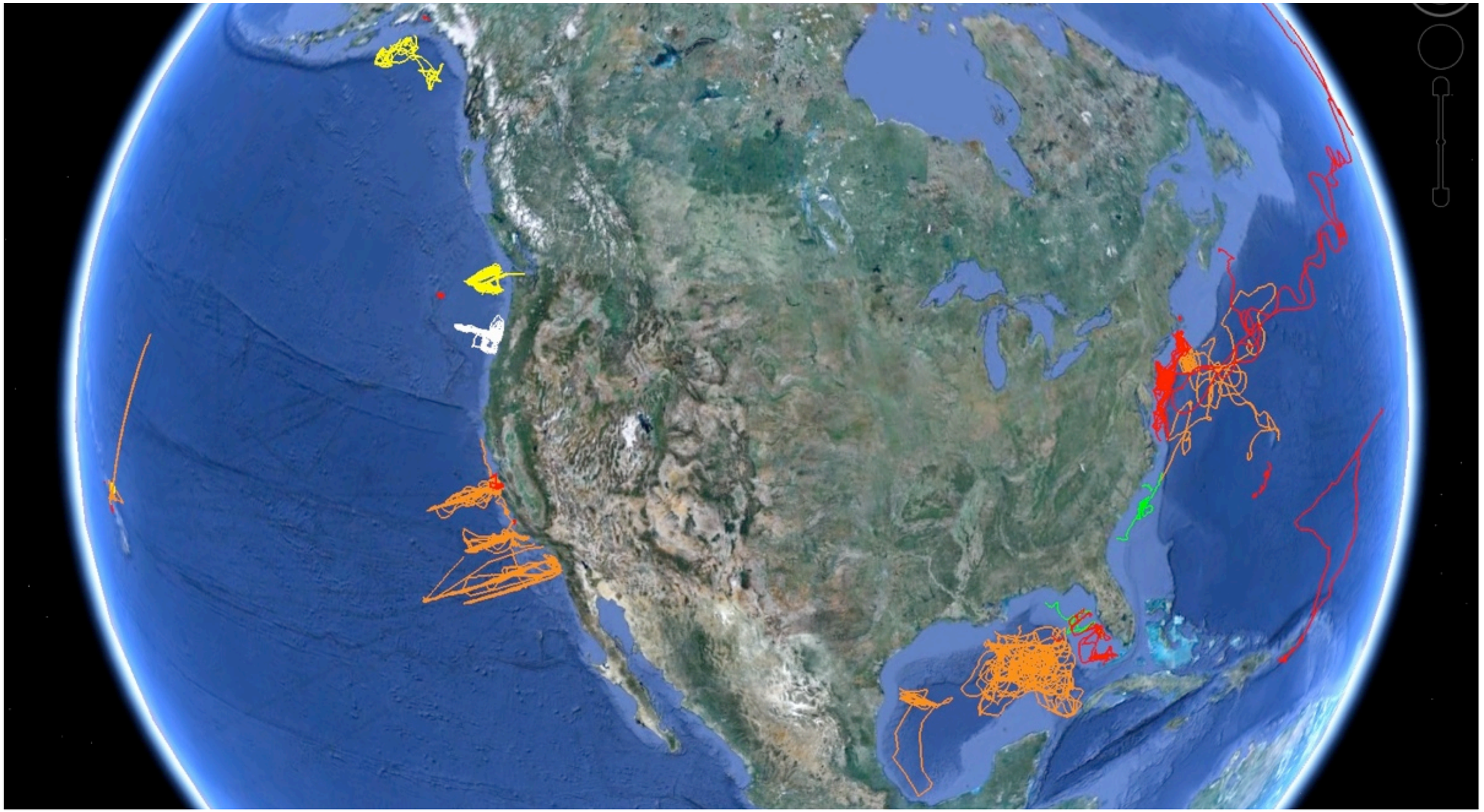
- "They migrate vertically through the ocean by changing ballast, and they can be steered horizontally by gliding on wings at about a 35 degree angle. They generally broach the surface six times a day to contact Mission Control via satellite. During brief moments at the surface, they transmit their accumulated data and receive instructions telling them how to steer through the ocean while submerged. Their speed is generally about half a knot."
- "the backbone of our climate monitoring capability is our permanent fleet of 480 [gliders]"

Argo



- The ocean's role in climate
- Global observation system for sustained observation of ocean temperature, salinity, velocity

Glider observations on the US coast



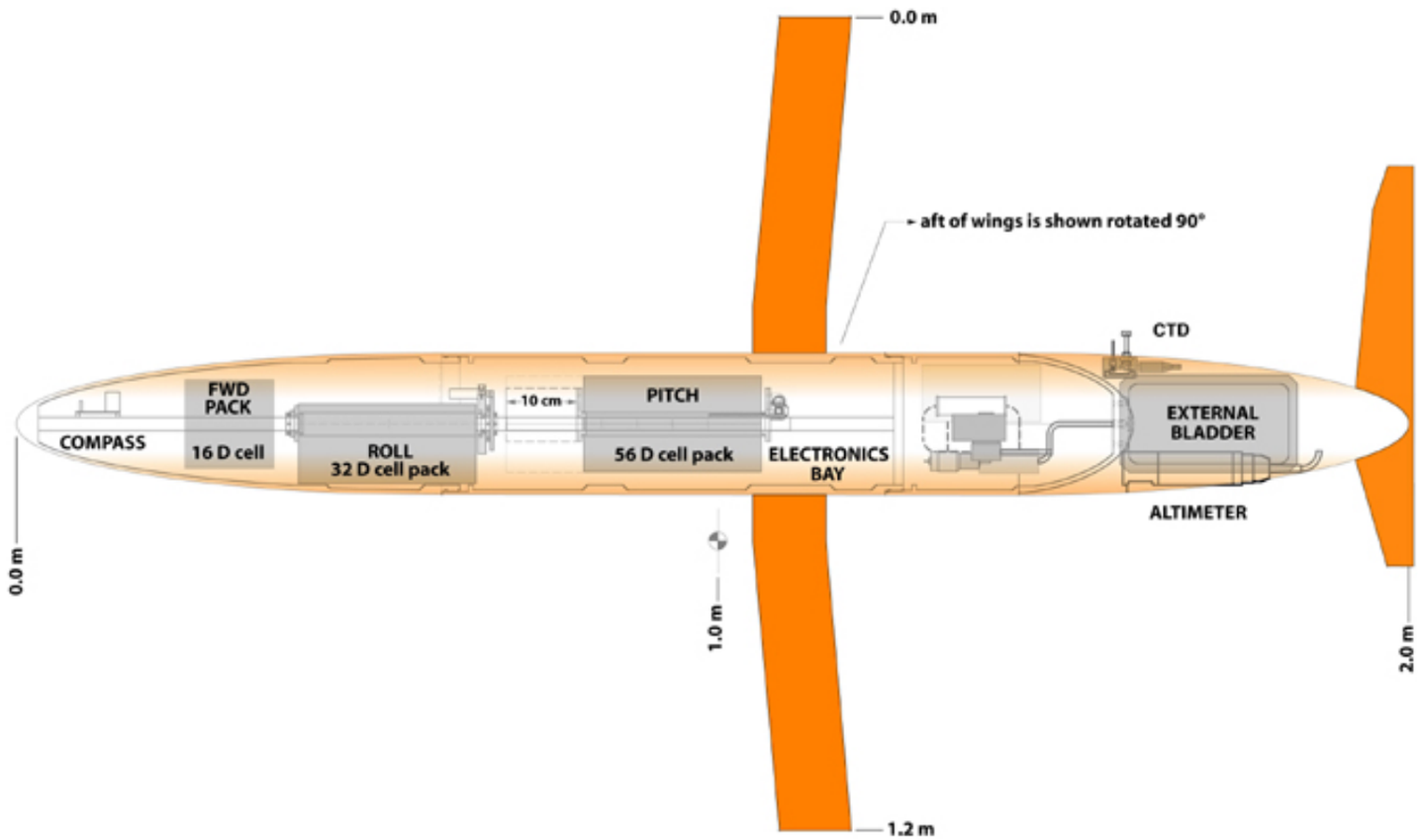
- Gliders' role in ocean observing system is to patrol the boundaries

A national glider network

- Large-scale, long-term baseline observations
- Connect coast with open ocean
- Societal, scientific, operational issues too large for a single region to address

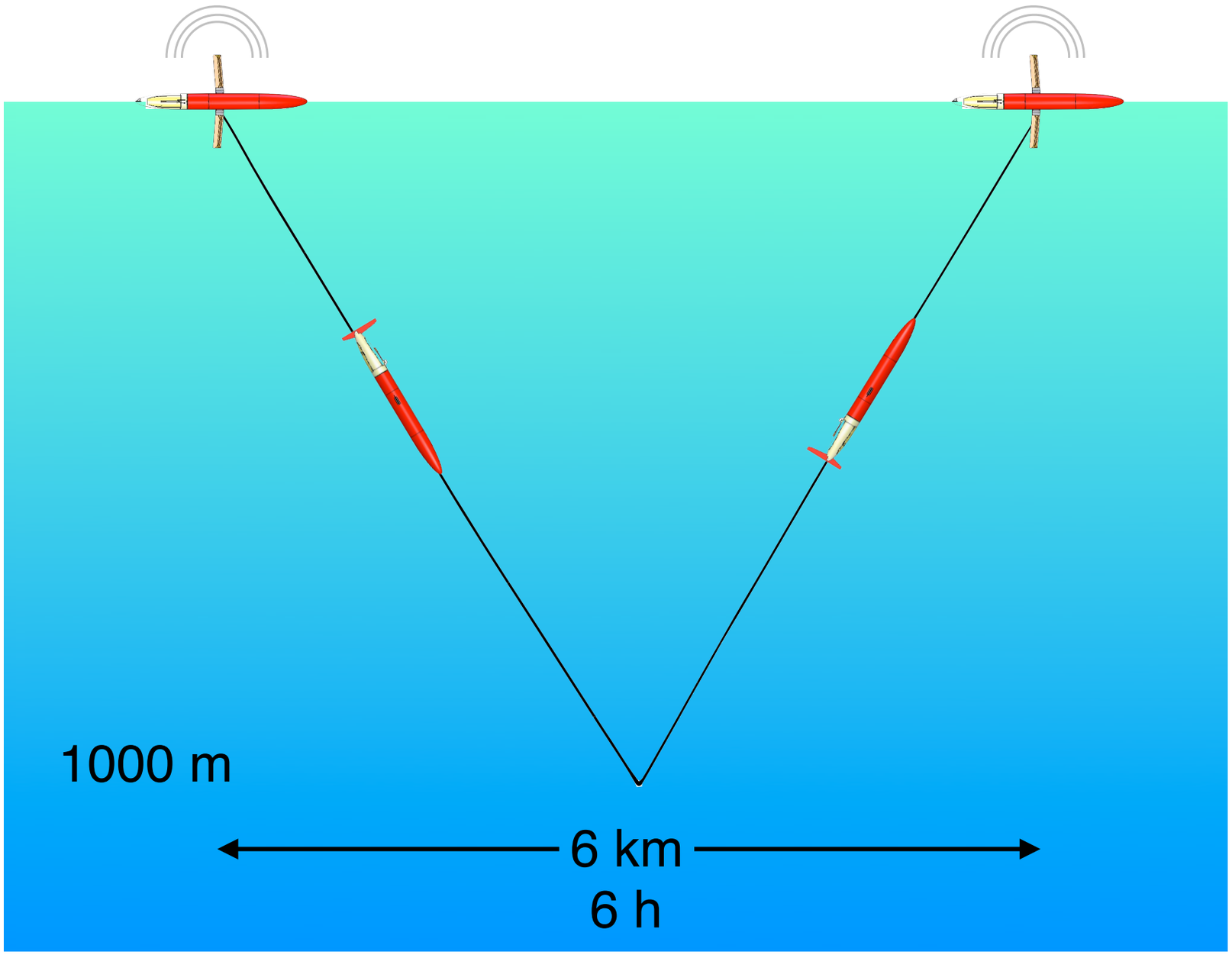
- Alongshore scales of hundreds of kilometers
- Across shore scales of kilometers
- Time scales of weeks
- Practical, achievable with a national glider network

Underwater glider



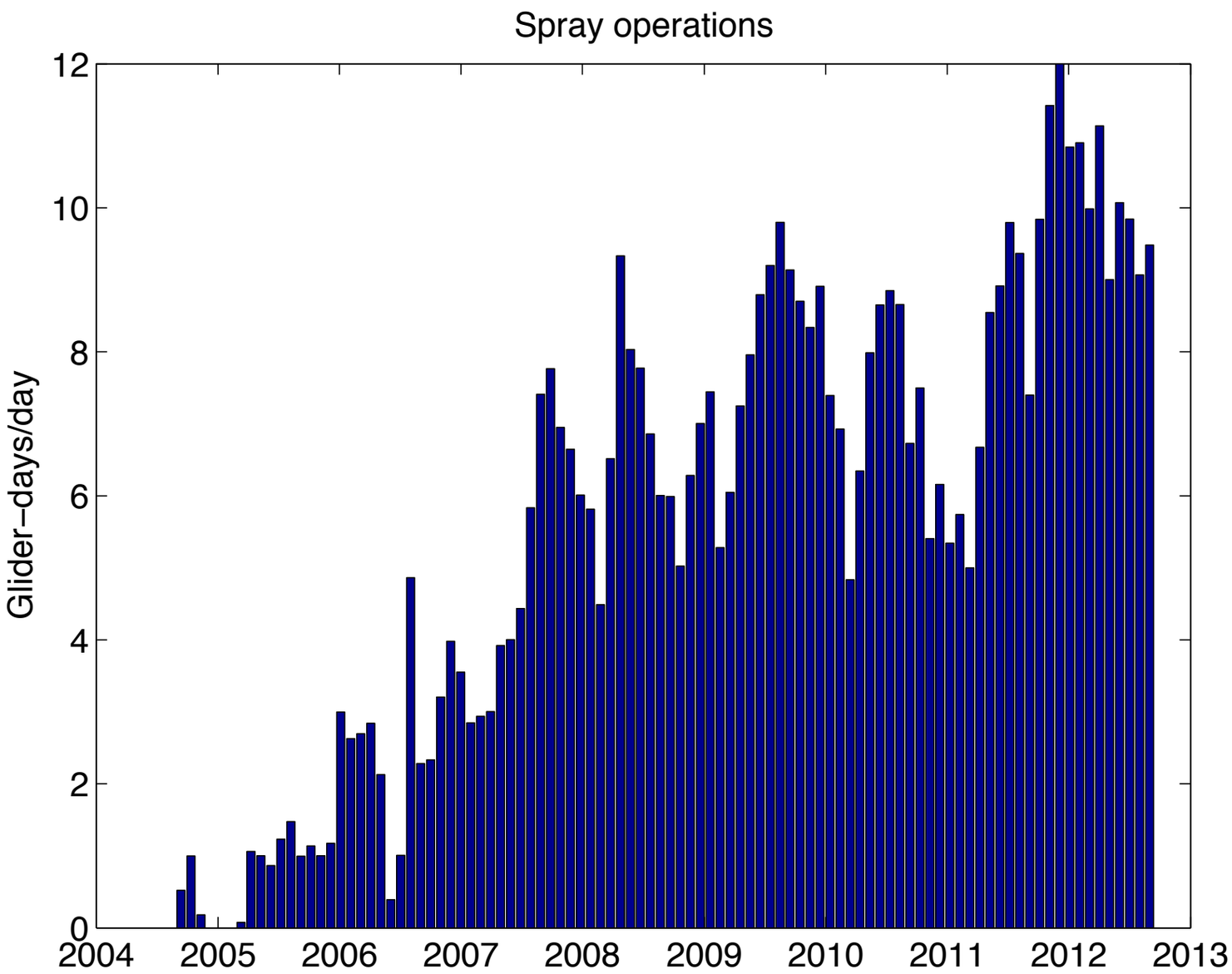
- Weight: 50 kg, Length: 2 m, wingspan: 1 m
- Profiles by changing buoyancy
- Steers by changing center of mass
- 2-way Iridium communication
- GPS navigation
- Pressure, temperature, salinity, velocity, chlorophyll fluorescence, acoustic backscatter, nitrate, optical backscatter, ...

Glider operations



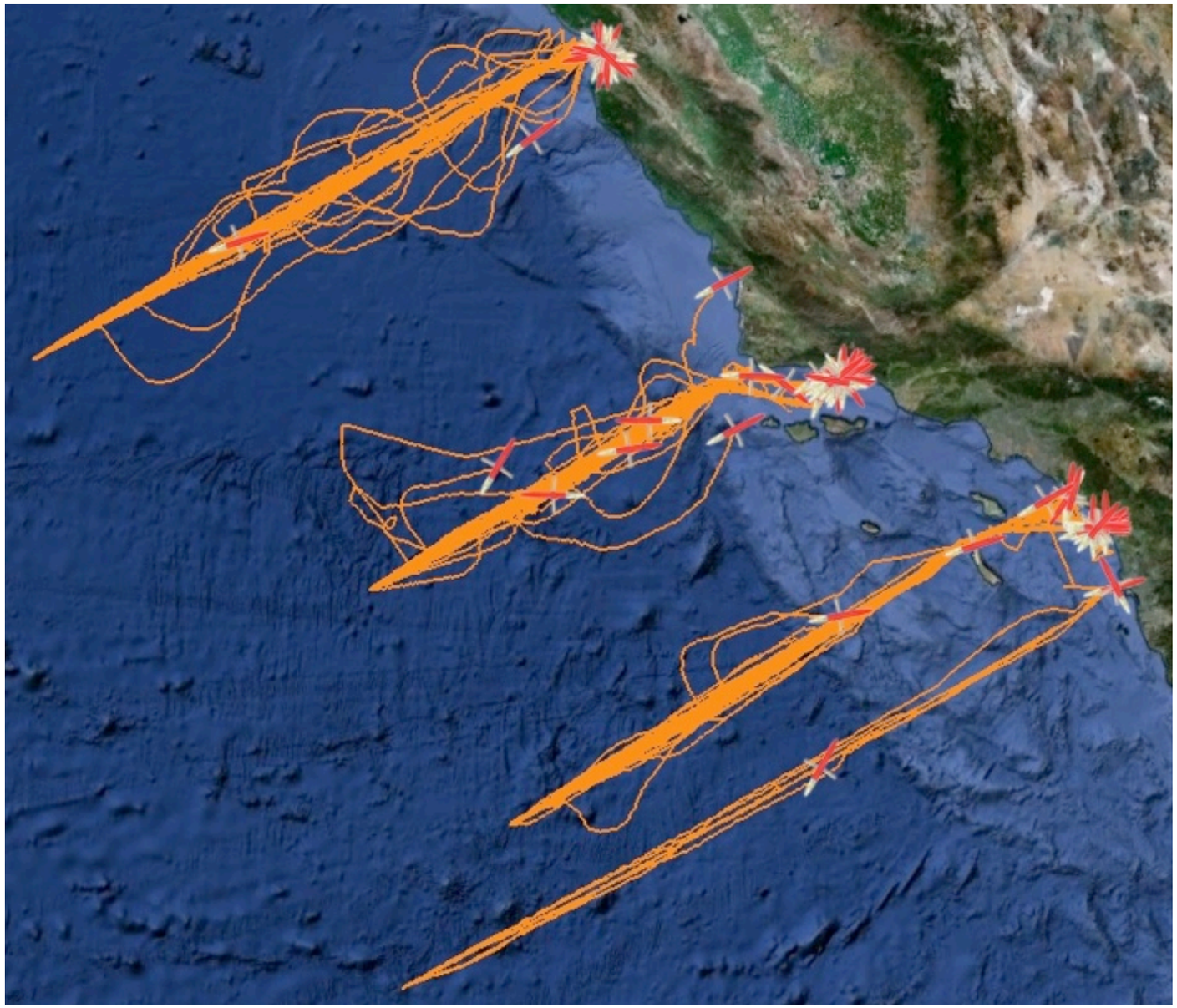
- Cycle 0-1000 m, 6 km, 6 h
- Horizontal velocity: 0.25 m/s
- Vertical velocity: 0.1 m/s
- Typical duration: 3-6 months
- Endurance depends on sensor suite, stratification, dive depth, speed

A growing enterprise



- Glider-days/day in 30-day averages
- Improving ability to sustain glider observations
- Averaging 10 gliders in the water over the last several months

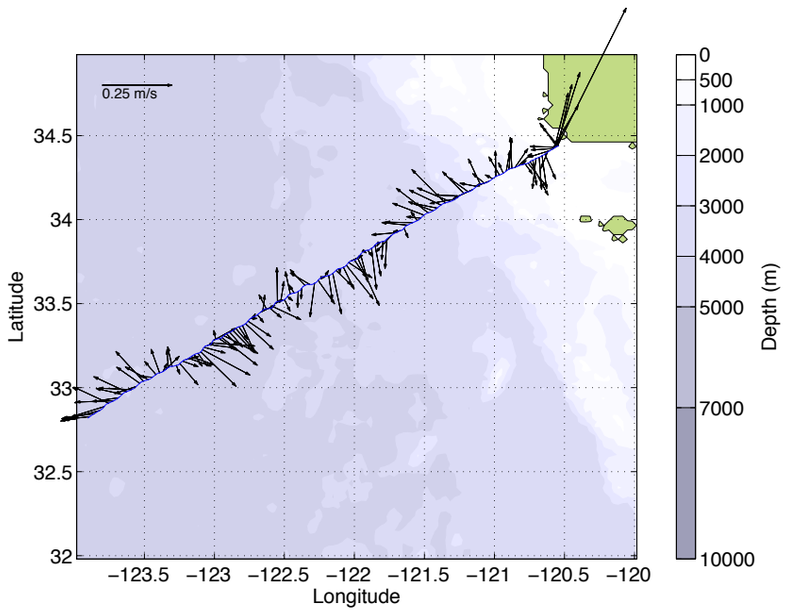
California Glider Network

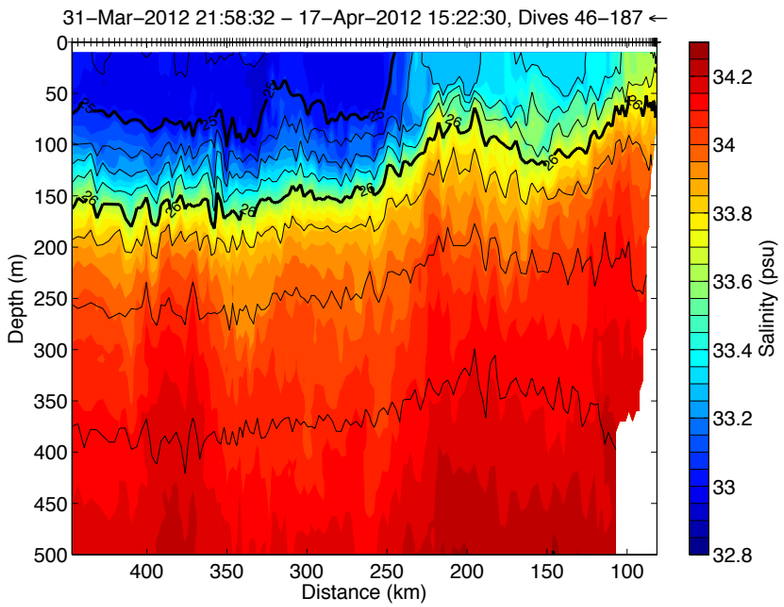


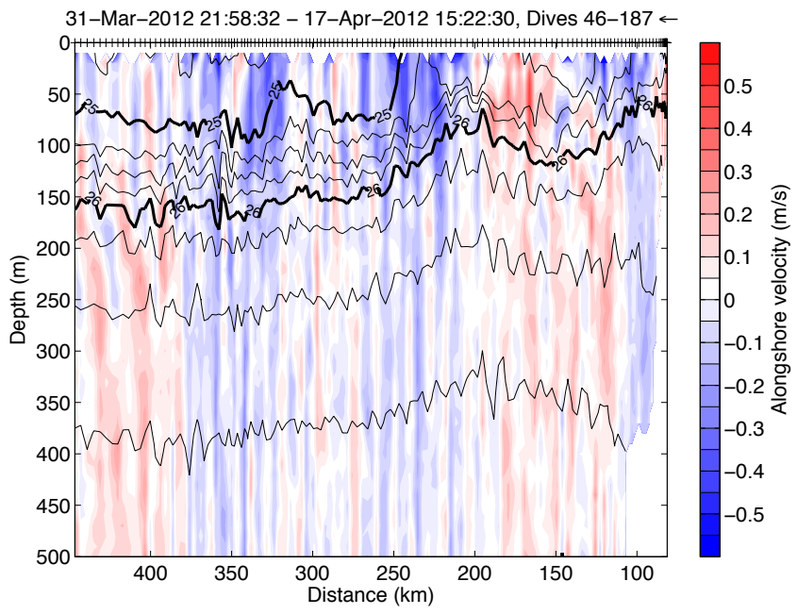
Southern California Coastal Ocean Observing System (SCCOOS)
Central and Northern California Ocean Observing System (CeNCOOS)

- Spray underwater gliders are part of a system to observe regional effects of climate variability
- Sustained since 2006
- Sections repeated every 3 weeks
- 129,681 km over ground
- 141,581 km through water
- 6284 days
- 58,209 dives

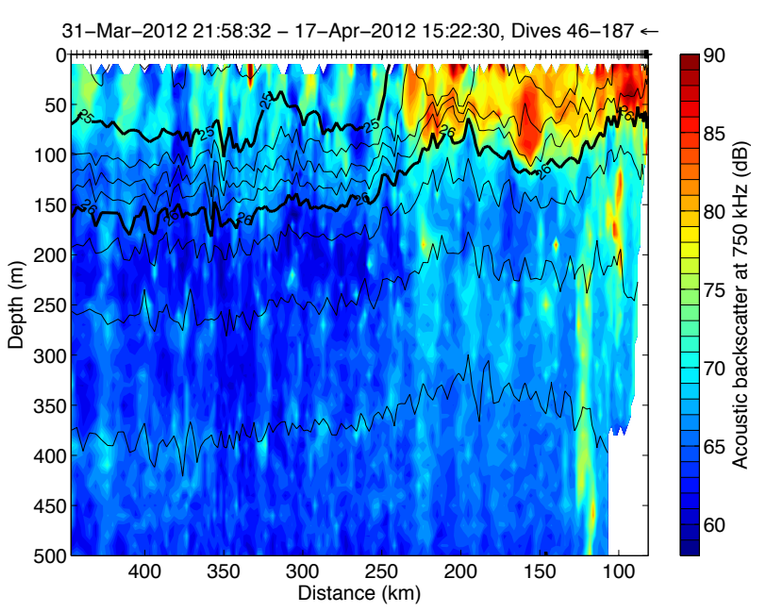
Sections on CalCOFI line 80

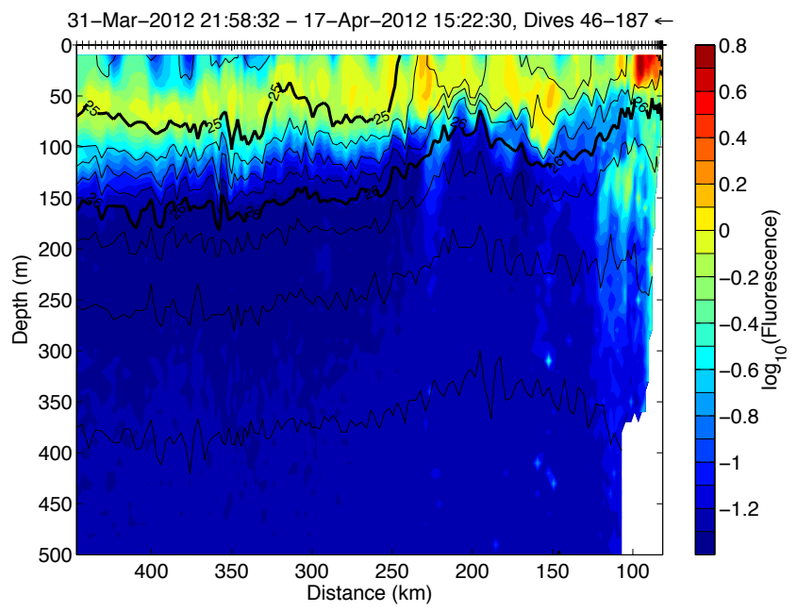




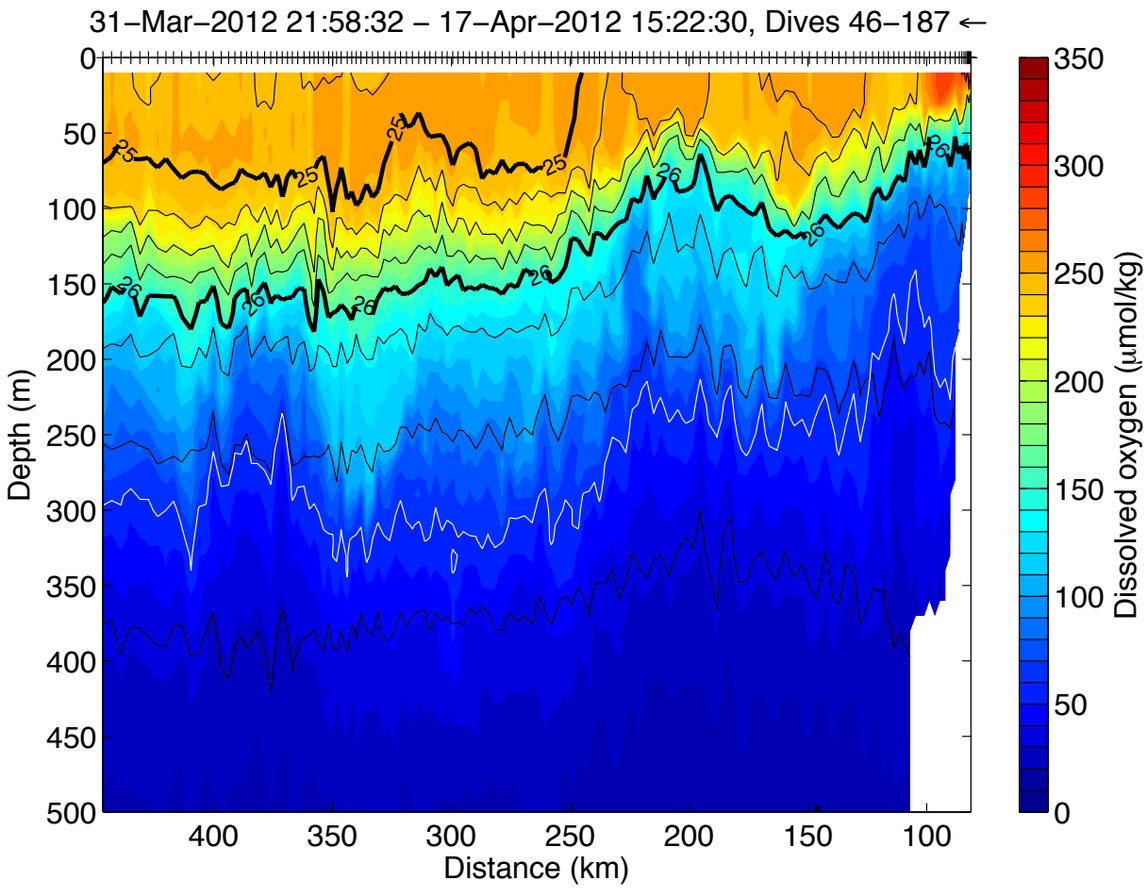


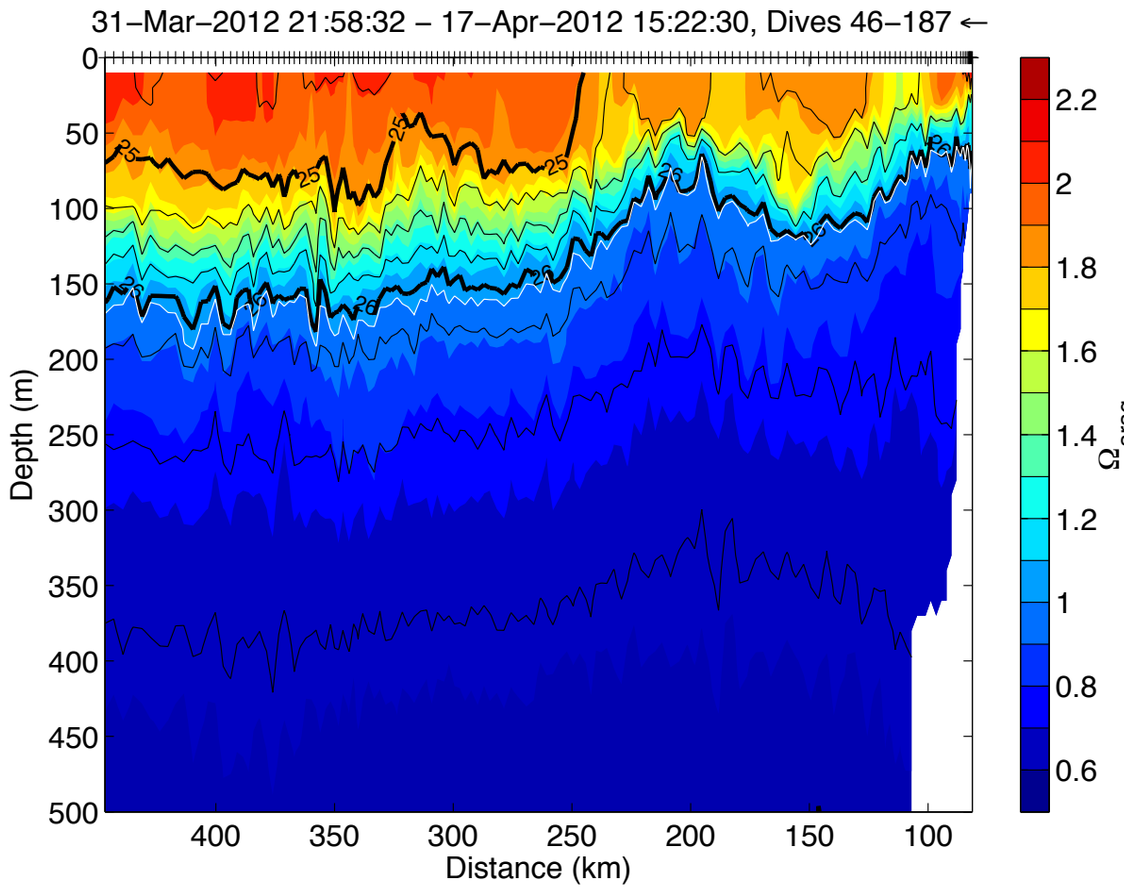
- 31 Mar - 17 Apr, 2012
- Depth-average velocity
- Salinity
- Along-shore velocity
- Acoustic backscatter
- Chlorophyll fluorescence



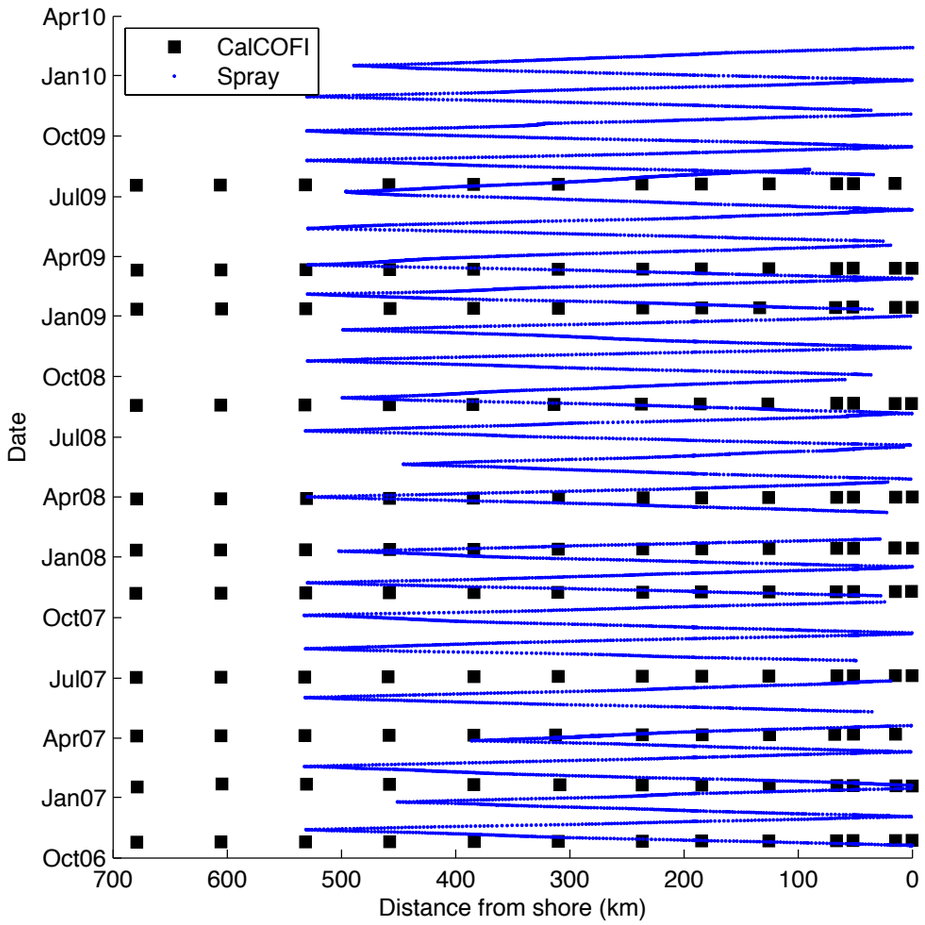


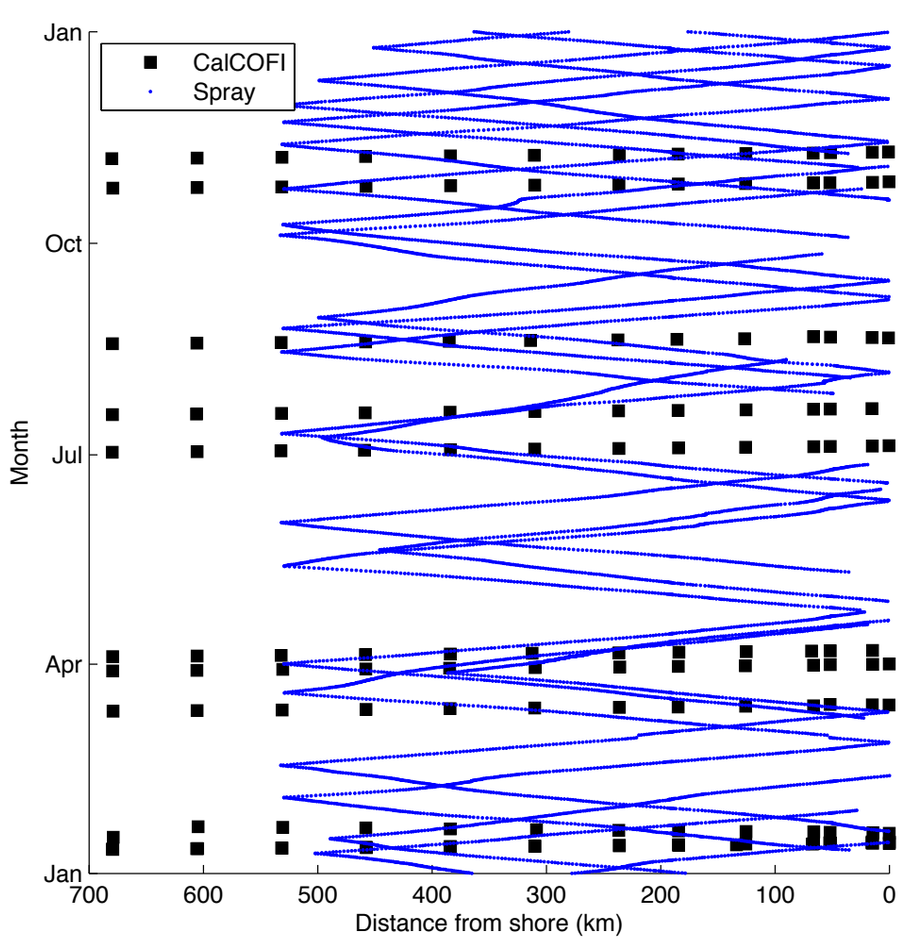
Dissolved oxygen and ocean acidification





- Upwelling causes hypoxic, corrosive water to shoal near the coast
- Using a proxy relationship to derive aragonite saturation (Alin et al. 2012)
- pH sensors will soon be available



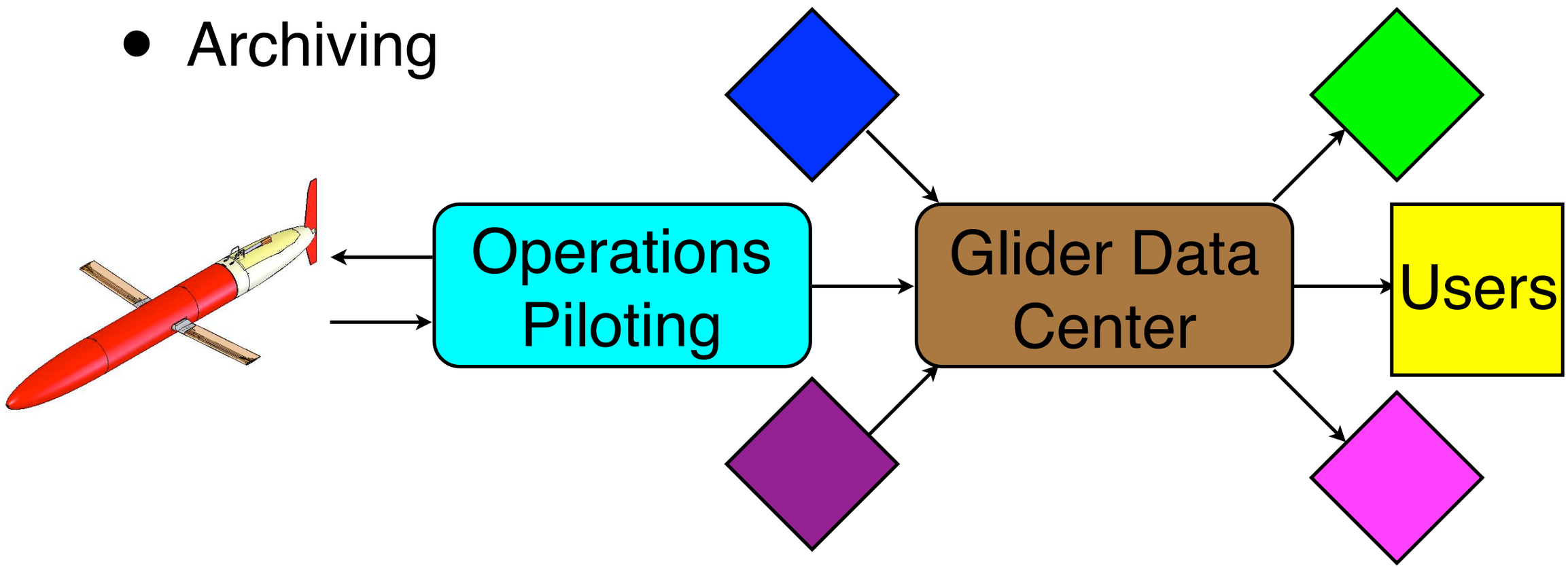


Glider sampling

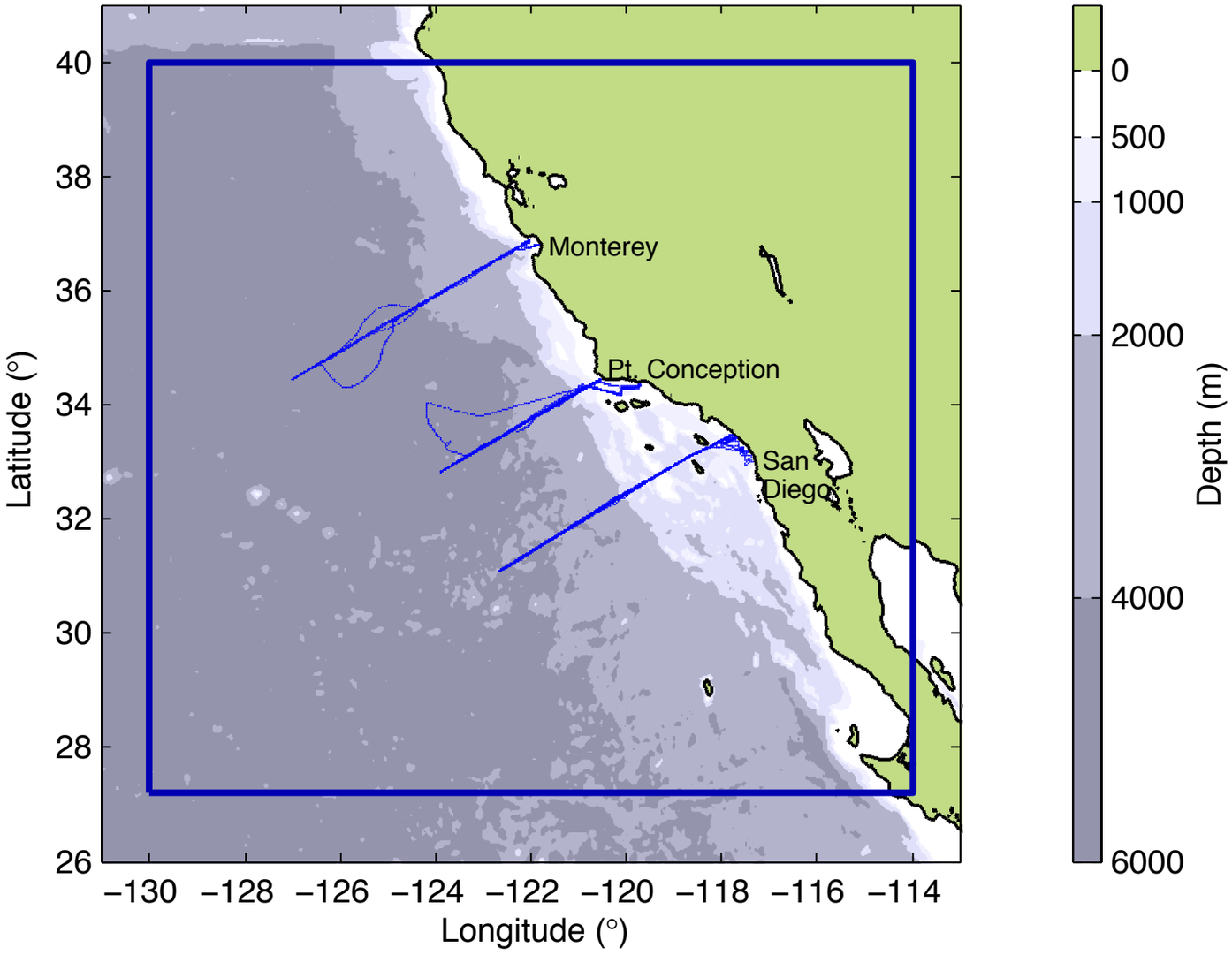
- Line 90
- Roughly 50 times as many glider profiles as ship stations in the same time period
- A virtue of gliders is continual presence.
- Annual cycle resolved in only 3 years

Data management

- National standards to ease exchange of data from regional glider operators
- Real-time distribution
- Quality control
- Delayed-mode distribution
- Archiving



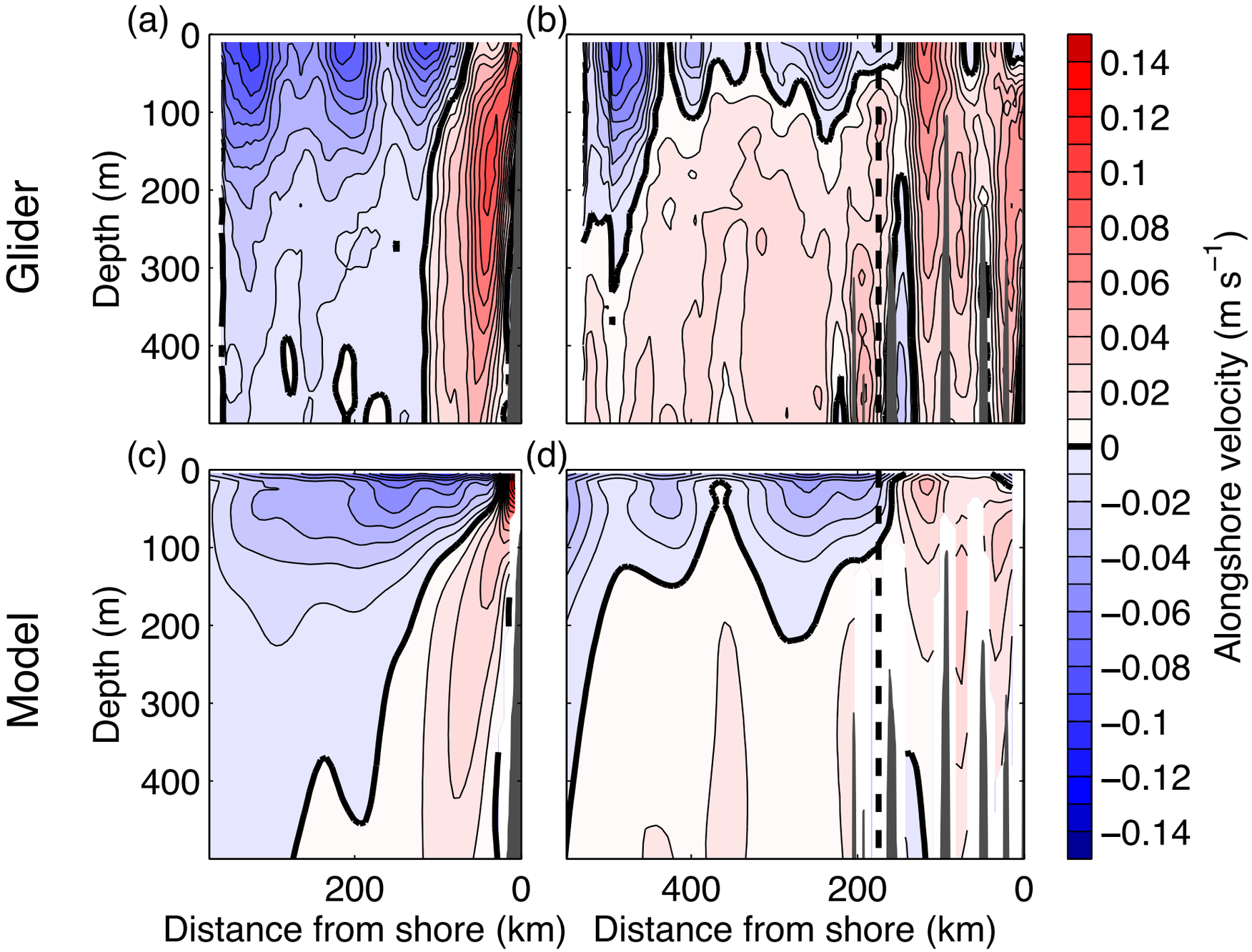
Data assimilation with gliders



- MITgcm
- 1/16°
- 72 vertical levels
- Surface forcing by NCEP reanalysis
- IC/BC: Forget 2009
- Assimilating gliders, Argo, CalCOFI T/S, satellite SSH, SST

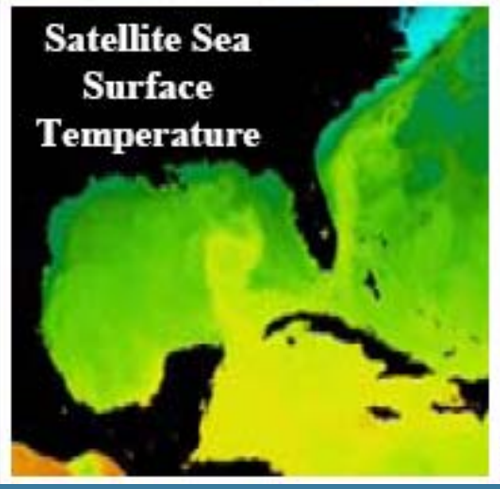
Robert Todd
Matt Mazloff
Bruce Cornuelle

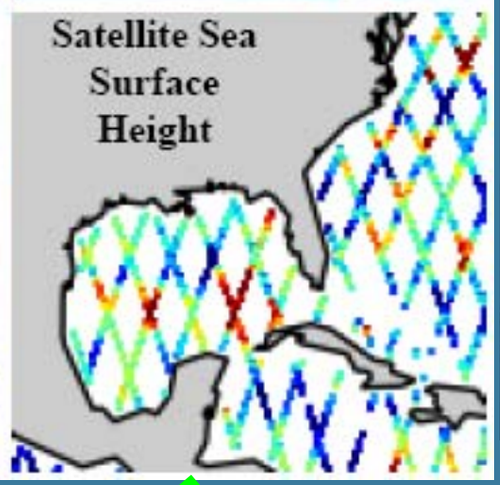
Mean alongshore velocity

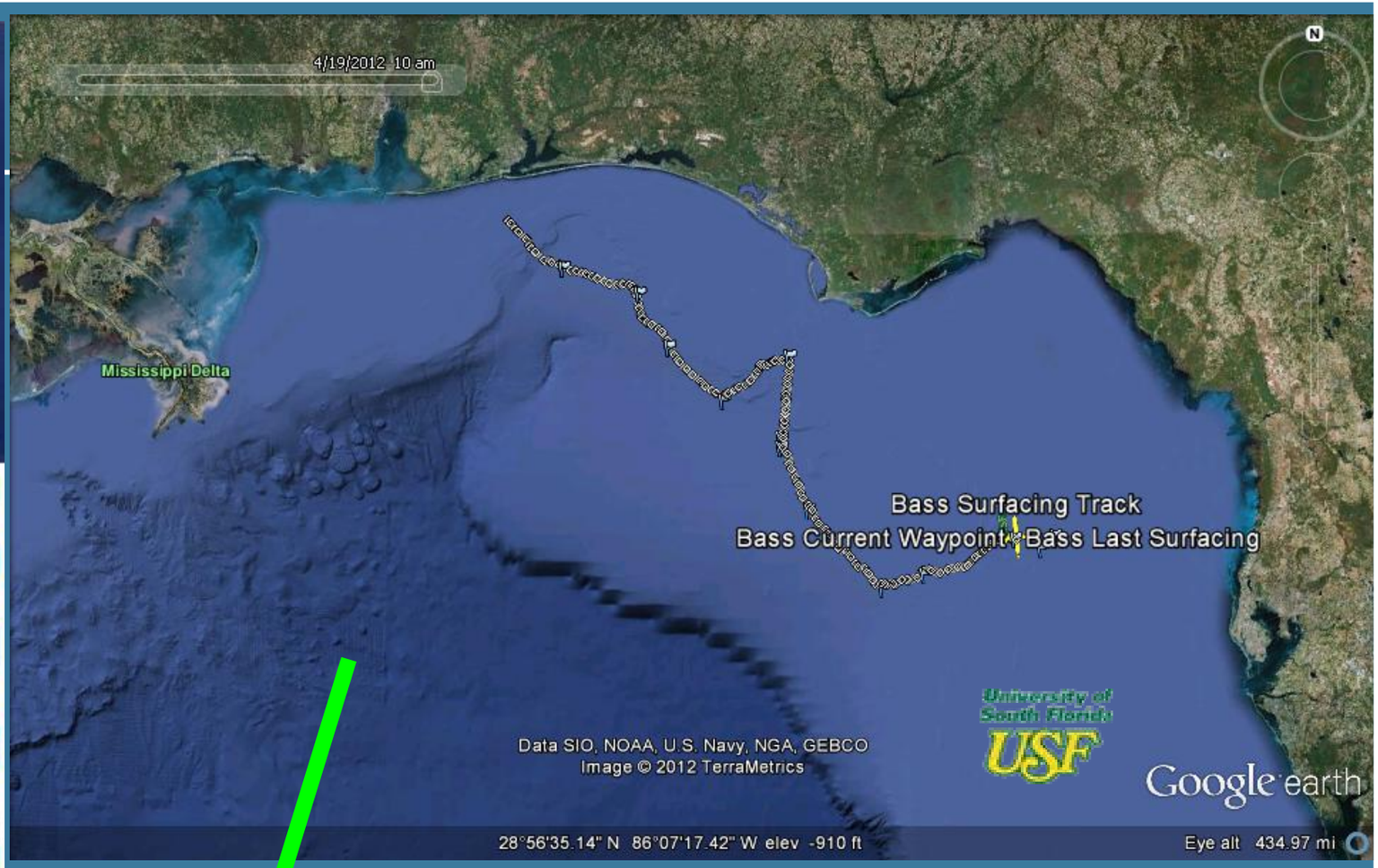


Line 80 Line 90

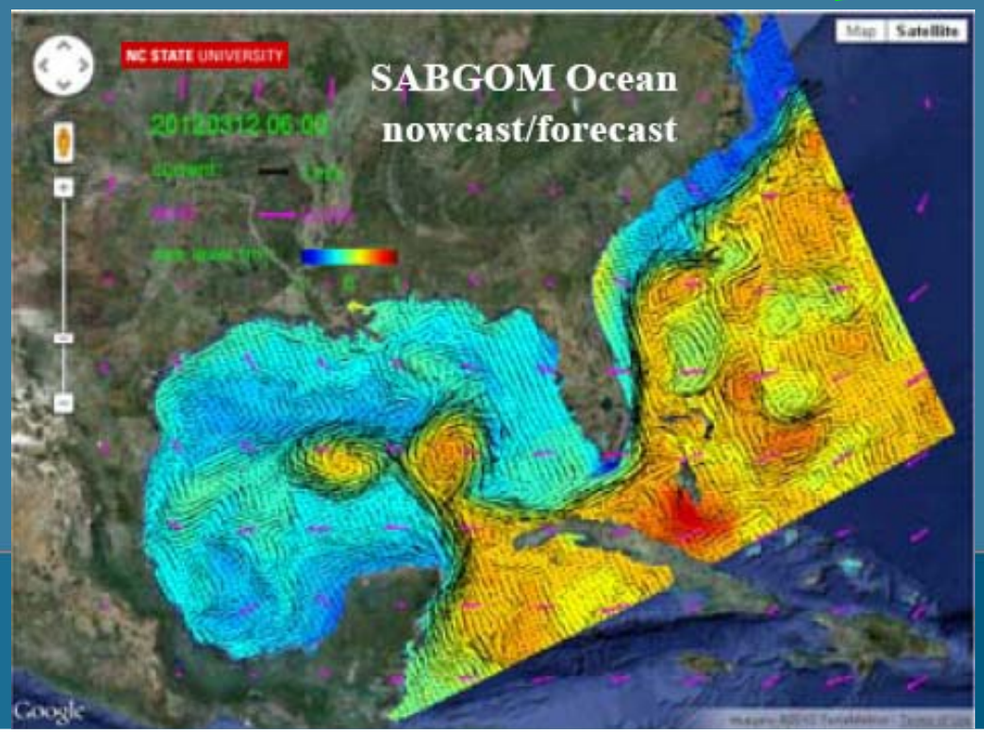
- Undercurrent apparent in cores of poleward flow
- California current is broad equatorward flow offshore near surface
- Remarkable agreement between data and model

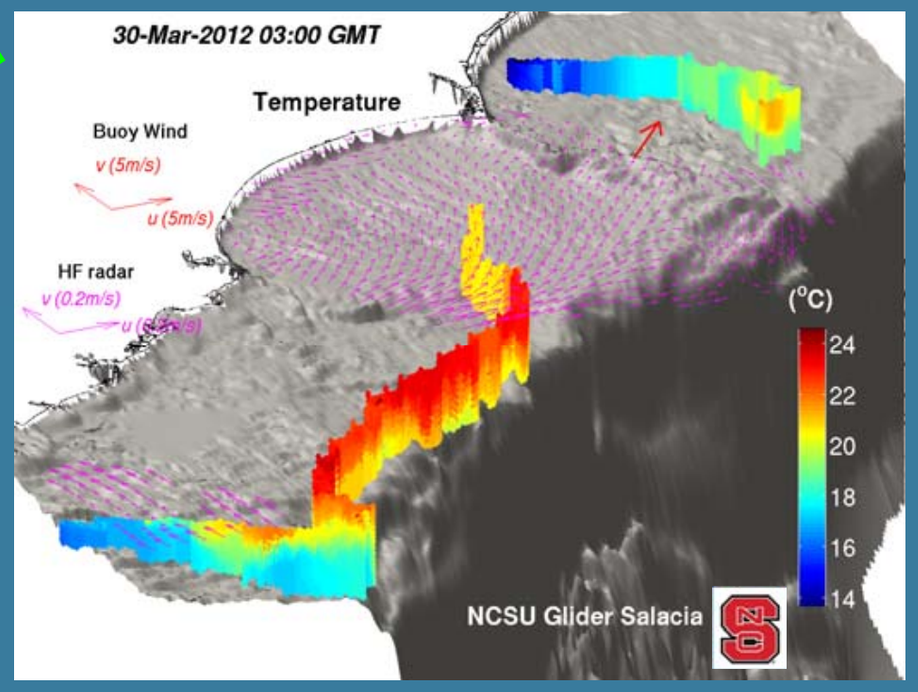






linking
Model
&
Data





IOOS

SECOORA
Southeast Coastal Ocean Observing Regional Association

Summary

- Societal and research priorities require sustained observations in the coastal ocean
- Underwater glider technology is suitable for the task
- Experience with sustained operations proves readiness
- Data management requirements are relatively straightforward
- Modeling and prediction centers use glider data, make products

Why a network?

- Important problems larger than any single region can address
- By working together we can establish a network to address these problems
- The network approach is proven: Argo, HF radar
- A national network will provide an infrastructure that will benefit regional efforts

A national glider network